Statistical Models for Understanding the Enduring Conventional and Nuclear Weapons Stockpile

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The LANL Statistical Sciences Group (CCS-6) executes a broad range of applied work to facilitate understanding of the enduring conventional and nuclear weapons stockpiles. The effort involves developing methods and software tools, appropriate data collection, and implementing solutions to help with stockpile stewardship for stockpiles. The technical issues associated with understanding the stockpile are complex and involve diverse data types and sources. Our goal is to provide improved confidence in future weapons reliability, safety, and performance. CCS-6 works within LANL to apply the best methods to improve the understanding of weapon assessment, complex system reliability, and to support decision making about the enduring U.S. stockpile.

Much of this work has been a continuing effort in research methods for the health assessment for complex systems. Each weapon in the stockpile is an aging system of dynamic parts. Many of these parts are tested individually, but new methodology and tools are required to integrate the various data streams derived from these parts to enable decision-makers to better understand the nature of the stockpile. We validated much of this methodology in our collaborative partnerships with the DoD through the Munitions Stockpile Reliability Assessment project of the Joint Munitions Program. Partnering with DoD collaborators provides a way to test and validate our methods [1]. DoD systems provide a data-rich environment, in contrast to our Stockpile Stewardship work.

Our recent successes in supporting the weapons program have included work in three major elements: statistics-based quantification of margins and uncertainties (QMU), resource allocation, and age-aware analyses and reliability assessments.

We have developed statistics-based QMU methodologies for combining separate tests, and physics and engineering codes to map the effect of input variation and aging effects on performance [2,3]. We have also created new methods for combining data from surveillance and experiments with physics simulations to provide performance-based lifetime assessments. We have formulated new resource allocation methodology to guide the choice of future types and quantities of tests to be collected for predictive, age-

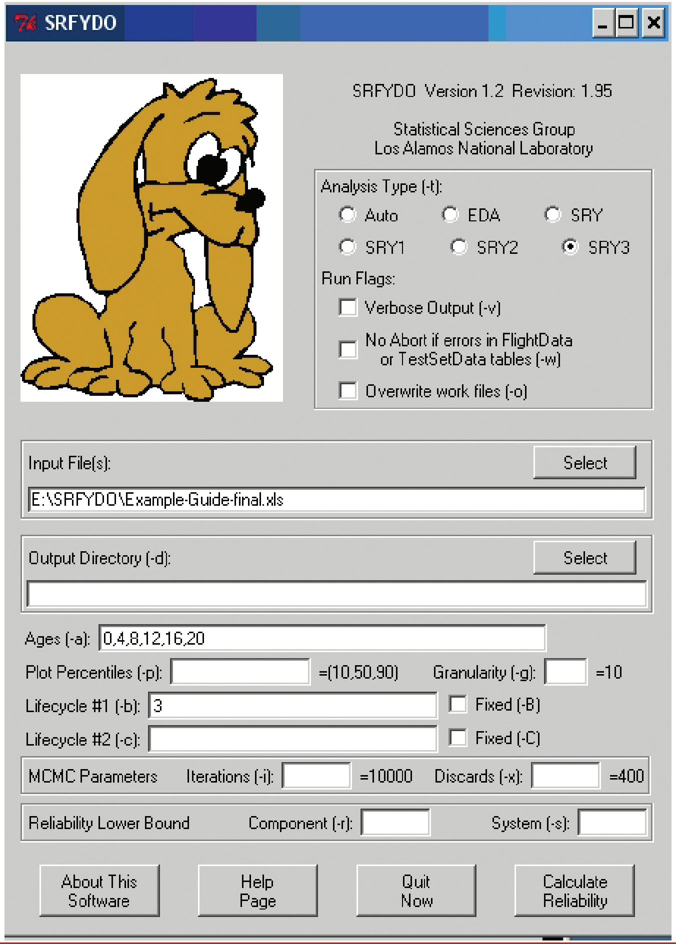

Fig. 1. Graphical user interface for the SRFYDO software tool developed for system reliability and prediction using Bayesian methods.

aware reliability assessment [4] and methodology to integrate heterogeneous sources of data into age-aware system-level reliability assessments with quantified uncertainty. For example, we developed methods for aggregating reliability uncertainty for a specific subsystem of the B-61 with Sandia National Laboratories. We have also performed age-aware assessments of components and stockpile parameters critical to performance or engineering assessments [5-7].

Such tracking and trending of data of stockpile parameter data streams provides a context for understanding the stockpile data. We have developed software tools to facilitate, implement, and operationalize these statistical methods and models. For example, the newly developed SRFYDO [8] is an application designed to simplify the process of system reliability modeling and prediction using Bayesian methods and Markov chain Monte Carlo. In addition, we have created foundational work on Bayesian reliability [9], models for multilevel data using methods from Bayesian networks, graphical models, and imprecise probability [10].

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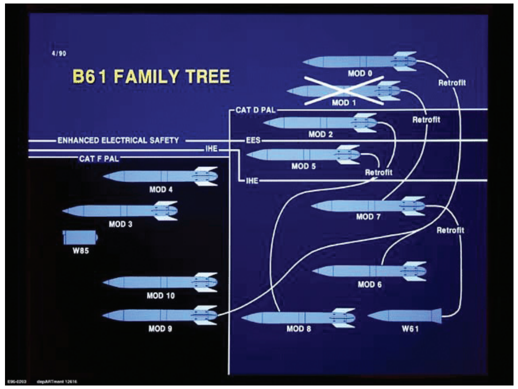

Fig. 2. Our reliability methods are developed in collaboration with DoD and LANL Core and Enhanced Surveillance for systems such as RAM and the B-61.

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